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WHAT IS CLAIMED IS:

5 1. An ultrasonic diagnostic system for the coherent detection of ultrasonic contrast agents comprising:

 an ultrasonic transducer probe for transmitting ultrasonic pulses into a body infused with an ultrasonic contrast agent and receiving ultrasonic echo signals following a pulse transmission;

10 a beamformer for forming coherent echo signals; means for differentiating coherent echo signals received from two pulse transmissions;

 means for detecting differentiated coherent echo signals; and

15 a display for displaying detected differentiated signals emanating from said ultrasonic contrast agent.

20 2. The ultrasonic diagnostic system of Claim 1, wherein said means for detecting comprises an amplitude detector.

25 3. The ultrasonic diagnostic system of Claim 2, further comprising an event discriminator for discriminating detected signals which emanated from a contrast agent.

30 4. The ultrasonic diagnostic system of Claim 3, wherein said event discriminator comprises means for comparing detected signals against a threshold level.

35 5. The ultrasonic diagnostic system of Claim 1, further comprising a B mode processor for producing B mode image signals, wherein said display displays a B mode image

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combined with the display of detected differentiated signals emanating from said ultrasonic contrast agent.

5 *Sub 41* 6. An ultrasonic diagnostic system for the detection of a harmonic ultrasonic contrast agent comprising:

10 an ultrasonic transducer probe for transmitting ultrasonic pulses at a first frequency into a body infused with an ultrasonic contrast agent and receiving harmonic ultrasonic echo signals following a pulse transmission;

15 a receiver for receiving harmonic signals emanating from said ultrasonic contrast agent;

a programmable filter which filters said received harmonic signals with a passband excluding said first frequency and including a harmonic of said first frequency; and

20 a contrast signal detector for detecting said received harmonic signals; and

a display for displaying received harmonic signals.

25 7. The ultrasonic diagnostic system of Claim 6, wherein said programmable filter comprises a programmable digital filter.

Sub 42 30 8. The ultrasonic diagnostic system of Claim 7, wherein the programmable characteristics of said digital filter include the weighting of received signals and the decimation rate of the filtered signals produced by said filter.

35 9. The ultrasonic diagnostic system of Claim 6, wherein said programmable filter comprises an FIR

filter.

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5 10. The ultrasonic diagnostic system of Claim 6, further comprising a B mode processor for producing B mode image signals,

wherein said programmable digital filter alternately provides signals for said B mode processor and said contrast signal detector.

10 11. The ultrasonic diagnostic system of Claim 10, wherein said programmable digital filter provides filtered signals for said B mode processor which include signals of a B mode passband and excludes said harmonic of said first frequency, and provides
15 filtered signals for said contrast signal detector which includes said harmonic of said first frequency and excludes signals of said first frequency.

20 12. The ultrasonic diagnostic system of Claim 6, further comprising means for rendering three dimensional images of said received harmonic signals.

25 13. A method for ultrasonically detecting the perfusion rate of tissue by ultrasonic contrast agents comprising the steps of:

introducing an ultrasonic contrast agent of microbubbles into the bloodstream; *and tissue*

transmitting an ultrasonic pulse which destroys microbubbles in said tissue; and

30 following the destruction of said microbubbles by a time interval, ultrasonically measuring the degree of microbubble reperfusion of said tissue during said time interval.

35 14. The method of Claim 13, further comprising

the steps of repeating said transmitting and measuring steps with a different time interval.

5 15. The method of Claim 13, further comprising the steps of repeating said transmitting and measuring steps with the same time interval.

10 16. The method of Claim 13, wherein said step of ultrasonically measuring comprises the step of acquiring echo signals following transmission of a second ultrasonic pulse into said tissue.

15 17. The method of Claim 16, wherein said step of ultrasonically measuring further comprises the step of creating an ultrasonic image with said acquired echo signals.

20 18. The method of Claim 17, wherein said step of transmitting comprises transmitting a relatively low frequency, high amplitude ultrasonic pulse into said tissue, and wherein said step of ultrasonically measuring comprises the step of transmitting a second ultrasonic pulse of relatively high frequency and low amplitude into said tissue.

25 *Sup*
 a 4 19. A method for ultrasonically imaging a region of the body which has been infused with a microbubble ultrasonic contrast agent comprising the steps of:

30 transmitting a first pulse into the body which is focused at a first depth within the body to cause a response from microbubbles located at said first depth;

35 receiving echoes following the transmission of said first pulse;

transmitting a second pulse into the body which is focused at a second depth within the body to cause a response from microbubbles located at said second depth;

5 receiving echoes following the transmission of said second pulse; and

producing an ultrasonic image from echoes received following said first and second pulses.

10 20. The method of Claim 19, wherein said first and second pulses are transmitted along substantially the same beam direction.

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15 21. The method of Claim 20, wherein said microbubble response comprises the destruction of microbubbles.

20 22. The method of Claim 20, wherein said steps of receiving echoes comprise receiving echoes from said first and second depths.

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23. The method of Claim 19, further comprising the steps of:

25 transmitting a third pulse following said first pulse which is focused at said first depth;

transmitting a fourth pulse following said second pulse which is focused at said second depth;

receiving echoes following the transmission of said third and fourth pulses; and

30 wherein said producing step comprises producing an ultrasonic image from the combination of echoes received following said first and third pulses, and from the combination of echoes received following said second and fourth pulses.

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~~19~~ 24. A method of ultrasonically imaging tissue whose perfusion has been enhanced with an ultrasonic contrast agent in the presence of a blood pool containing contrast agent comprising the steps of:

5 insonifying said perfused tissue and blood pool;
 receiving echoes returned from ultrasonic contrast agent in said perfused tissue and blood pool;

10 processing said received echoes for display by displaying greater intensity echoes with a lesser brightness or color intensity than echoes of lesser intensity,

 whereby said perfused tissue is highlighted in the display relative to said blood pool.

15 25. A method of ultrasonically detecting destruction events of microbubbles of a microbubble contrast agent present in the body comprising the steps of:

20 transmitting an ultrasonic wave which is destructive of microbubbles, said wave exhibiting a range of frequencies including a frequency which is destructive of microbubbles of a given size; and
 receiving ultrasonic signals following said
25 ultrasonic wave transmission,

 whereby said wave is destructive of microbubbles of a given range of sizes including said given size.

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(B) 26. A method of ultrasonically detecting a microbubble contrast agent present in the body by high PRF pulses comprising the steps of:

 transmitting a first ultrasonic pulse into the body which causes a first response from said microbubbles;
35 receiving a desired microbubble response to said

first ultrasonic pulse;

transmitting a second ultrasonic pulse into the body which causes a second response from said microbubbles;

receiving a desired microbubble response to said second ultrasonic pulse and an undesired echo response to said first ultrasonic pulse;

processing said received microbubble responses by incoherent detection, whereby said desired and undesired responses exhibit opposite polarities; and eliminating said undesired response.

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~~27~~. The method of Claim ²⁰~~26~~, wherein said first microbubble response is microbubble destruction and said second microbubble response is an absence of microbubble destruction.

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~~28~~. The method of Claim ²¹~~27~~, wherein said undesired echo response to said first ultrasonic pulse emanates from tissue located deeper in the body than microbubbles which cause said first response.

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~~29~~. The method of Claim ²⁰~~26~~, wherein said processing step includes the step of differentiating the received microbubble responses to said first and second pulses.

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~~30~~. An ultrasonic diagnostic system for the detection and display of ultrasonic contrast agents within the body comprising:

an ultrasonic transducer probe for transmitting ultrasonic pulses into a body infused with an ultrasonic contrast agent and receiving ultrasonic echo signals following a pulse transmission, including means for transmitting high and low energy

ultrasonic pulses;

a trigger circuit responsive to a physiological function for triggering high energy ultrasonic pulse transmission;

5 a contrast signal processor for processing echoes received in response to high energy pulse transmission;

a B mode signal processor for processing echoes received in response to low energy pulse transmission; and

10 a display for displaying simultaneous real time B mode images and triggered contrast agent images.

24 25 31. The ultrasonic diagnostic system of Claim 15 30, wherein said means for transmitting comprises means for selectively generating low frequency, high amplitude pulses or high frequency, low amplitude pulses.

24 26 32. The ultrasonic diagnostic system of Claim 20 30, wherein said trigger circuit is responsive to a heartbeat waveform.

27 33. An ultrasonic diagnostic system for the 25 detection and display of ultrasonic contrast agents within the body comprising:

an ultrasonic transducer probe for transmitting ultrasonic pulses into a body infused with an ultrasonic contrast agent and receiving ultrasonic 30 echo signals following a pulse transmission, including means for transmitting high and low energy ultrasonic pulses;

a trigger circuit for periodically triggering high energy ultrasonic pulse transmission;

35 a contrast signal processor for processing

echoes received in response to high energy pulse transmission;

a Doppler processor for processing Doppler echoes received by said transducer probe;

5 a B mode signal processor for processing echoes received in response to low energy pulse transmission; and

a display for displaying real time B mode images containing color Doppler image information and
10 periodically containing contrast agent image information.

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~~27~~ ³⁴ 34. The ultrasonic diagnostic system of Claim
15 ~~33~~, wherein said trigger circuit comprises means for triggering high energy ultrasonic pulse transmission in response to a heartbeat signal.

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~~27~~ ³⁵ 35. The ultrasonic diagnostic system of Claim
20 ~~33~~, wherein said real time images comprise colorflow Doppler images.

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~~27~~ ³⁶ 36. The ultrasonic diagnostic system of Claim
~~33~~, wherein the periodicity of said trigger circuit is selected by the system user.

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